Review of the state of water pollution affecting inland fisheries in Southeast Asia

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DEFINITION OF MARINE POLLUTION

Pollution of the marine environment means: "The introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) which results in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, impairment of quality for use of sea water and reduction of amenities".

IMO/FAO/Unesco/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP)

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ABSTRACT

Present and future potential problems of water pollution affecting freshwater fisheries in Thailand, Malaysia, Indonesia and the Philippines have been examined, together with current and proposed methods of prevention and control of such problems. Suggestions are offered on future cooperative action that might be taken in the region. These include recommendations for the establishment of a working group on water quality criteria and for the consolidation of information on simple treatment procedures used in the region.

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1. INTRODUCTION

1.1 Background

In 1972 the Swedish International Development Authority (SIDA) provided the services of A.E. Thorslund to assist FAO in its work on inland water pollution, and a visit was made to Thailand to assess the nature and extent of problems affecting freshwater fisheries, as well as to make recommendations on relevant legislation, administration, training, research and monitoring requirements (Thorslund, 1972). Later in the same year, the first of a series of FAO/SIDA training courses was held for participants from developing countries and the following year, as part of the follow-up, the organizers of the course visited several countries, including Thailand, Malaysia and the Philippines, to assess the benefits of such training and the potential need for further assistance (Andrén and Dybern, 1974). Their report considered the current fisheries resources, water pollution, and training and laboratory facilities.

The present study has been undertaken within the framework of the Indo-Pacific Fisheries Commission (IPFC), provision having been made 'for a consultant to visit some countries in the region to assess the state of pollution in their waters and to propose follow-up actions' (IPFC, 1984), and the Working Group on Aquaculture having already particularly identified the problem of mining wastes and the predominance of organic wastes. The main purpose of the survey has been to review the situation in Thailand, Malaysia and the Philippines and to evaluate it for the first time in Indonesia.

It should be added that the water legislation in Thailand and the Philippines had already been reported on by the UN (Vendiola, 1967) and in Malaysia and Indonesia by FAO (Caponera, 1978) and that comprehensive proposals for water legislation in Malaysia have been put forward recently by FAO (Wilkinson, 1984).

1.2 Layout of the Report

Although there would be some merit in discussing the whole situation in each country in turn, in that links between legislation, administration and research would then be most easily seen, to avoid undue repetition and to bring out the elements common to all countries visited, some subject areas are dealt with separately.

1.3 Acknowledgements

The author had the opportunity to meet many, but not all, relevant organizations and key personnel in South East Asia, as listed in Appendix 1, and he is most grateful to them, and many others besides, for all the help given in arranging visits and in providing information. Incomplete though the survey was bound to have been in the relatively short time available, it is felt that it provided sufficient opportunity to gain a generally representative picture of the situation, so that the conclusions drawn, while not necessarily comprehensive, are reasonably well-founded.

2. MEASURES TO CONTROL WATER POLLUTION

2.1 Thailand

Thailand has a well-defined national policy on the prevention and control of pollution embodied in the Improvement and Conservation of National Environmental Quality Act, 1975, as amended by the corresponding Act of 1978 (Thailand, 1983). This established the National Environment Board (NEB), giving it responsibility to report to and to advise the Council of Ministers, the Prime Minister and relevant government bodies on environmental matters, including standards, legislation, remedial measures and research.

NEB has carried out surveys of river quality both directly and by contracting others, such as the Asian Institute of Technology (AIT), although surveys are also carried out by other bodies, including the irrigation authorities, the Ministry of Public Health and the universities. It has also listed the types of projects and activities that would require 'Environmental Impact Assessments' (EIAs), including effects on fisheries (Thailand, 1981) and it has drawn up EIA guidelines (Thailand, 1980). It has announced some environmental standards and is in the process of defining others, e.g. for freshwater fish; it has also drafted effluent standards for domestic effluents, for instance.

The powers of NEB, however, are limited. The actual control of water pollution is exercised mainly by the Ministry of Industry under the general provisions of the Factory Act, 1969 (Thailand,

1969), as revised in 1975. This ministry performs a number of duties: (1) it issues licences for effluent discharges; (2) it prescribes effluent standards (e.g. Thailand, 1982), which at present are generally uniform for a given industry for all water quality characteristics, except for suspended solids, for which the standards are related to dilution in the receiving stream; (3) it revises the standards; for example, it made those for biochemical oxygen demand (BOD) more stringent in 1983; (4) it imposes penalties for non-compliance, which can include closure of the factory, and (5) it requires the performance of treatment plants to be monitored, undertaking much of the work itself, although at present it is able to cover only about one third of the estimated 6 000 discharges.

The Ministry of Public Health is involved with sanitary aspects of water pollution and collaborates with the fisheries field officers when fish kills occur.

There is no means of controlling agricultural wastes, such as those from piggeries near the Tha Chin River. However, NEB is currently involved in formulating guidelines for the use of piggery wastes as manure.

NEB is to set up regional offices next year, but there are no plans as yet to establish regional pollution control bodies, although the view is often expressed by government officials and environmental scientists that such bodies would be the most effective administrative unit for water quality management, e.g. by Pescod (1977), a view shared by many of those in Thailand and elsewhere, as listed in Appendix 1.

2.2 Malaysia

The Environment Quality Act, 1974, empowers the Department of Environment (DOE) of the Ministry of Science, Technology and Environment to licence point emissions, discharges and deposits of waste into inland waters and to specify acceptable conditions. Fixed emission standards have been promulgated by Regulations for two specific industries (palm-oil and rubber processing, in 1977 and 1978 respectively) on the basis of the best available technology, after consultation with industry and the Malaysian Rubber Research Institute. These standards have been made progressively more stringent as research on treatment proceeded (Maheswaran and Singham, 1985) and there has been strict enforcement. For sewage and other industrial effluents, two sets of standards were applied by Regulation in 1979, taking account of available expertise and costs of treatment, the more stringent of the two applying to discharges upstream of potable supplies.

DOE has also issued guidelines to the Federal States and other responsible agencies on: (1) zoning and siting of industries; (2) EIAs; (3) prevention of erosion and siltation, and (4) selection of sites for solid waste disposal and site management (new legislation being envisaged to deal with the disposal of toxic and hazardous wastes (Maheswaran and Singham, 1985).

Other existing legislation dealing with matters bearing upon water pollution affecting fisheries, such as mining operations (see Maheswaran and Ho, 1983), though comprehensive in range, has been found deficient in dealing with the problem. There is a division of responsibility between federal and state governments and many departments have an interest. A revision of the law has been put forward for a multidisciplinary approach, with coordination of state and federal plans, provision of inter-state, inter-basin development and effective control of non-point sources of pollution (Wilkinson, 1984). The need for the inclusion of all aspects of water resource management to achieve an adequate analysis of the implications of planning, construction and operation and maintenance programmes has been emphasized by Bower and Hufschmidt (1984) and a strong plea for a single authority with comprehensive powers together with the administration of river basins by regional water authorities has been made by Maheswaran and Ho (1983).

Monitoring is achieved by DOE through quarterly reports required of effluent dischargers, and by its own spot checks, although the latter are necessarily infrequent because of the size of the task. Where problems arise, more detailed river studies are carried out.

The University of Malaya (funded by the UN University) is carrying out a 3-year multidisciplinary river basin study of the complex Linggi River system. However, the project is in jeopardy because, at the most critical time of the year, from July to September, during the dry spell following the monsoon in May and June, teaching duties severely restrict the amount of fieldwork that can be done. Added to that is the difficulty of attracting high-calibre temporary technical staff at salaries lower than those offered to permanent staff.

DOE is also carrying out river basin studies, particularly where there are indications that water quality has deteriorated, although its manpower resources are limited. Mathematical modelling of river water quality is not yet well developed.

2.3 Indonesia

Enabling legislation has recently been made available under Act 4 of 1982 concerning Basic Provisions for the Management of the Living Environment. This states, inter alia, that: (1) protection shall be based on environmental standards; (2) EIAs will be required for new developments, and (3) there should be overall and sectoral prevention and abatement of pollution. All of this is to be established by legislation, some of which is now in draft form, e.g. water quality criteria for fish (Badruddin, 1983) and effluent standards, on which a cabinet decision is anticipated this year. It is envisaged that effluent standards, of which there are four categories, depending upon the circumstances, will take account of the carrying capacity of any sub-system (Hardjasoemantra, 1983). Several have also promulgated effluent standards which, if necessary, may be allowed to be more stringent than the national standard.

There is provision for coordination at the national level (although the necessary supporting legislation is not yet available) but implementation of national policy will be carried out at the regional level by provincial governments in accordance with existing legislation. Thus a large number of bodies is involved, as detailed by Caponera (1978), including the Departments of Mines, Public Works and Electricity, Agriculture and Fisheries. However, by Presidential Decree, the Ministry of Population and Environment is the coordinating body; administrative arrangements are under discussion to secure multidisciplinary control of water quality management in catchment areas shared by more than one provincial administration.

Also, by Presidential Decree, the duties of the Ministry of Industry include: (1) licencing of new industries; (2) approving plans for waste disposal and giving guidance on treatment; (3) cooperating with other interests at the local level, including fisheries; (4) coordinating any necessary research; (5) determining damages, and (6) implementing temporary stoppages of pollution.

Responsibility for routine monitoring of water quality currently rests with the Directorate for Water Research, which also carried out analyses of fish on request, but has not yet worked on freshwater species.

2.4 Philippines

There is a well-defined national policy for the prevention and control of water pollution (Lesaca, 1978; Philippines, 1978, 1982), coordinated by the National Pollution Control Commission (NPCC) and administered by a large number of national and local bodies. Many of the numerous relevant pieces of legislation covering water and waste management have been listed (Vendiola, 1967; de Sagun and Bautista, 1979; Philippines, 1982a). The responsibilities of the NPCC include: (1) conducting public hearings concerning pollution problems; (2) establishing, with the help of ad hoc groups water quality criteria, which it has done (in 1978) for different uses of water, including fisheries, although these criteria are regarded as preliminary; (3) establishing (in 1982) effluent standards for sewage and different types of industry, depending upon the type of waste and where it has to be discharged, as well as upon political and socio-economic factors; (4) monitoring of water quality, including (over the last two years) concentrations of metals and pesticides in water and in fish at the fingerling and harvest stages, and (5) classification of rivers based on water quality and best usage (i.e. some rivers may have to be improved in quality to meet the criteria). The NPCC hopes, in due course, to study the assimilative capacity of rivers and to develop mathematical modelling. It has the power to act as arbitrator for damages, to recommend the treatment of wastes according to guidelines provided by the Department of Local Government and Community Development and, ultimately, the closure of polluting industries (which it has done on several occasions), although it is recognized that there may be valid financial constraints to waste treatment in some industries.

There are five NPCC regional offices and laboratories for water quality monitoring but no overall water quality management by single catchment authorities for river basin areas except in one case, Laguna de Bay (Centeno, 1985).

The Laguna Lake Development Authority (LLDA) was established in 1966, at which time it had research and development of resources as its main goals, but in 1976 it also embraced resources conservation. Until 1983 it acted for NPCC by agreement but now NPCC powers have been devolved and it has begun to prepare relevant rules and regulations, including modification of existing criteria and standards to take account of dilution, especially in the case of effluents. The water quality criteria are regarded as only tentative, to be revised in the light of new scientific information on the water quality requirements of indigenous fish and also of future changes in the desired water uses, e.g. from fisheries to water supply.

The legislation has also established the National Environment Protection Council (NEPC) with responsibility, inter alia, for (1) rationalizing the functions of government agencies charged with environment protection and law enforcement; (2) formulating policy and recommending legislation; (3) undertaking research, and (4) reviewing EIAs (Philippines, 1984). For the latter purpose it has produced a comprehensive handbook (Alcances et al., 1983).

Solid waste disposal is handled by local governments working with the NEPC, which has been operating a subsidy programme since 1979 (Philippines, 1984a), but the control is regarded as ineffective, there having been press reports of wastes reducing dissolved oxygen (DO) to zero in some rivers (Parañaque, San Juan and Zapote).

2.5 Conclusions

Within the last ten years there has been rapid development of pollution control legislation, generally involving the establishment of national coordinating authorities for environmental protection, as well as the provision of specific powers of pollution control through environmental and effluent standards.

Effluent standards have often been tailored to the problems from particular industries and situations, as well as to best available treatment technology, with a growing recognition of the importance of relating the standards to the assimilative capacity of the receiving water and to realistic environmental standards including those for fish.

Multi-disciplinary river basin management, while generally recognized as being desirable and being under active consideration, is not yet a reality in practice, mainly because a large number of bodies is currently involved, particularly at the local level.

3. NATURE AND EXTENT OF POLLUTION PROBLEMS AFFECTING FRESHWATER FISHERIES

3.1 Sewage and Industrial Wastes

3.1.1 Thailand

Sewerage is virtually absent in Thailand so that pollution from domestic sewage is considerable, especially in rivers adjacent to large conurbations (e.g. in the Chao Phraya, flowing through Bangkok, it contributes the bulk - 65% - of the total BOD load discharged) and result in very low concentrations of DO. Sewering of the whole of Bangkok to a central point for treatment is prohibitively expensive, but a scheme is being developed to assess the feasibility of dealing with separate areas, the first of which holds about 7% of the population.

Oxidizeable organic wastes from agriculture-based industries, such as food processing plants, piggeries, distilleries, pulp and paper mills and textile factories, were another main source of water pollution in the recent past, having caused de-oxygenation and fish kills. Ten years of monitoring of water quality in 34 main rivers by the Environmental Health Division of the Department of Health of the Ministry of Public Health, has shown that seven are badly polluted in terms of low DO, although there has been a marked improvement in one, the Mae Klong, where intensive remedial work has been carried out (e.g. Phantumvanit et al., 1976).

3.1.1.1 Water quality modelling

The relationship between organic load and DO in the worst affected river, the Chao Phraya, has been studied by AIT, but is not well understood, although a mathematical model has been developed (Lohani et al., 1981); the main difficulty is in estimating the organic load itself from Bangkok, although there is also uncertainty concerning the choice of appropriate values for aeration and respiration rates. Work has been halted for lack of funds.

The Mekong River in the north-east, forming part of the border with Laos, has been studied for many years, but it suffers from only localized problems in Thailand, mainly from organic human, agricultural and papermill wastes. A mathematical model which has been developed to predict salinity will be extended in the next three years, with the help of consultants, to include other water quality characteristics, including toxic substances and DO. It is then expected that the model will be taken over by the countries concerned and that a laboratory will be built in Thailand to provide for that country's contribution (Comit- Int-rimaire du Mekong, 1983).

3.1.1.2 Waste treatment

Industrial effluents from the larger factories are given treatment, but for the very large number of industries in Bangkok that are too small to provide their own treatment facilities, it is proposed to try to establish four centralized treatment units. Such an approach has been made on the Mae Klong river, where the Ministry of Industry has established, and directly supervises with his own staff, a plant collecting the waste from a large number of factories, predominantly those processing sugar cane (Thantoolavest, 1984). The result is that, whereas there were massive kills of fish reported in the river in 1969 (Thorslund, 1972), there are now none, the river being high in DO (Thailand, 1982). The treatment comprises nutrient addition and passage through anaerobic and stabilization ponds; a high crop of fish was reported last year from the ponds in the downstream half of the series (at least 700 kg/ha in one 15-ha pond).

Similar lagoon treatment accounts for nearly 60% of the treated organic load discharged to the rivers flowing into the Gulf of Thailand. Holding-ponds are common but a few plants (13.7%) use evaporation and incineration (for distillery waste) or activated sludge (2.7%).

3.1.1.3 Solid waste

At present, it is estimated that only about 80% of the solid waste in Bangkok is collected (including items such as car batteries) but feasibility studies have been carried out to investigate the possibility of composting market wastes and of making use of land-fill (which poses special problems because of the high water table).

3.1.1.4 Future developments

Future developments are embodied in the 6th National Social and Economic Development Plan to 1987. The annual rate of growth of population, which was 3% in 1972, has now fallen to about 1.5% and the long-term objective of the Ministry of Public Health and family planning organizations is 1.4%.

Industrial development is scheduled not for Bangkok but for the eastern seaboard of the Gulf of Thailand where there is already an oil refinery and one gas storage plant, which will be joined by a gas separation plant next year; the feasibility of a petro-chemical complex is also being examined. Pollution problems from these developments are, therefore, likely to affect sea fisheries rather than those inland.

Some developments are, however, also planned for inland areas, namely at Chiang Mai in the north-west, Khon Kaen and Nakhon Ratchasima in the east, and Hat Yai and Songkhla in the south. But the approach will be optimize, rather than maximize, exploitation of the resources, after having estimated the assimilative capacity of the areas in question.

3.1.2 Malaysia

3.1.2.1 Palm-oil and rubber

Up to 1977 there was an ever-increasing pollution of Malaysian rivers caused principally by the organic load from palm-oil mills and rubber factories (John, 1978; 1978a); there was also a drastic decline in both wild and cultured fish production, though partly attributable to increased exploitation (Jothy, 1978). The precise causes of the decline are not known, but there have been massive kills of fish from lack of DO (Sreenivasan, 1978) and indications from chemical analyses of heavy pollution of the Kelang River (Law and Mohsin, 1980) and, elsewhere, of high concentration of ammonia, as well as BOD, often associated with rubber factories (Lim, 1980).

The situation today is greatly improved, for much of the BOD load has been reduced (80-85% of that from palm-oil and 85-90% of that from rubber processing). It now seems clear that the major part of the existing organic load derives from domestic sewage and animal husbandry, particularly from piggeries.

3.1.2.2 Treatment of wastes

Most (85%) of the treatment of wastes from rubber and palm-oil processing is through lagoons (aerobic and facultative) but some is recirculated - a practice strongly encouraged by DOE - or utilized, with significant economic gain, for irrigation of the palms. The annual production of rubber

is unlikely to increase more than 10-15% in the next 10 years, so that a continuing reduction in pollution from that source is to be expected. Some further increase in palm-oil production is predicted, but much of the effluent is used in irrigating the palms and, although the effluent is more polluting than that from rubber, the industry lends itself more easily to the provision of centralized treatment facilities. The hope is that palm-oil wastes will also be used for methane production in the future.

Only a part of Kuala Lumpur and of Penang together with two small new towns are sewered. In these cases the treatment given is centralized anaerobic digestion and aeration or, for the new housing estates, lagoon systems: the latter are sometimes inadequately designed, generally being too deep, so that fish living in the facultative ponds may suffer periodic mortalities at night. Control of sewerage, which is through the local authorities, is not necessarily very effective, there being a need for centralized coordination. There is back-log in the implementation of the Master Plan so that provision of sewerage is now of high priority (Maheswaran and Singham, 1985). The approach with piggery wastes will be to try to relocate them for treatment.

3.1.2.3 Industrial wastes and future developments

The range and complexity of water pollution problems from industrial effluents from the manufacturing sector have increased, particularly from the development of the electronic and electro-plating industries; other sources include tanneries, textile mills, food processing, distilleries, chlor-alkali plants, rubber products and chemical works, and significant concentrations of heavy metals have been recorded in some rivers (Maheswaran and Singham, 1985). The problem is likely to worsen in the future for, besides a current annual rate of population growth of 2.7%, which will increase water demand generally, usage by industry, which was 4% in 1980, will increase to 8% by 1990 and to 16% by the year 2000 (Maheswaran and Singham, 1985). The urban population is also expected to increase from 37.8% of the total in 1980 to 45.5% in 1990 and the manufacturing sector by nearly 11% (Pang and Chi, 1983).

Peninsular Malaysia has a density of population about 1.7 times that of Eastern Malaysia and also has the greater development of urban and industrialized areas; it therefore suffers most from water pollution problems which also tend to be concentrated in coastal areas and the adjacent inland strip of land.

3.1.3 Indonesia

3.1.3.1 Pollution of rivers

Most domestic waste in Indonesia is untreated, resulting in high organic loads to rivers, especially in urban areas such as Jakarta. Problems with oxidizeable wastes have also been encountered with the processing of tapioca, palm-oil and rubber, the wastes of which are generally discharged untreated. Wastes from tapioca may also depress the pH of the receiving stream.

Fish kills have been observed from time to time in several rivers, including the Musi River in Sumatra where there is a large fertilizer plant periodically discharging urea and ammonia. Arsenic compounds, phenols and chlorinated phenols are used in timber preservation and are suspected of causing adverse effects in the Kalkapa River, Kalimantan.

Monitoring of over 100 rivers has been carried out since 1979 by the Institute of Hydraulic Engineering and several are considered to be polluted. Some of them show deterioration, especially in urban areas, including the Citarum River, where a pilot study for general water quality management is being conducted in collaboration with the Ministry of Technical Coperation, the Federal Republic of Germany and Aachen University. In other rivers only inventories of sources of pollution are being compiled. Industries that are present include textile, metallurgical, pharmaceutical, pulp and paper and food processing (Badruddin, 1983). In 1982 there were eleven pesticide formulation plants (Partoatmodjo and Alimoeso, 1982); currently, there is one pesticide manufacturing plant and more are planned for the future.

3.1.3.2 Treatment of wastes

A pilot installation for wastewater treatment is being operated at Cimahi near Bandung, using first physical and chemical treatment and adding a biological stage later (Badruddin, 1983), followed, it is hoped, by use of the effluent for rice and fish culture. Otherwise no special treatment is provided for such wastes as those from palm-oil and rubber processing.

3.1.4 Philippines

3.1.4.1 Pollution of rivers

NPCC considers, from its own water quality monitoring, that, of over 400 rivers (not all of which have yet been studied), 50 are affected by pollution problems (de Leon and Abiog, 1983) and 40 are virtually dead as a result of low DO and high concentration of hydrogen sulphide, suspended solids and heavy metals, four of these being in metropolitan Manila. Domestic sewage is probably one of the main sources of organic wastes, especially near the larger cities like Manila, where planned sewerage (to convey the sewage directly to the sea) has yet to be built. Refuse also contributes substantial pollution loads to such rivers. There are additional large inputs of organic wastes from agriculture-based industries; in the Bulacan River, for example, such sources include piggeries, tanneries, poultry production units as well as other sources such as textile factories and pulp and paper mills. Elsewhere, sugar-processing and distilleries have caused problems, e.g. in the rivers Palico and Bagbag, where they caused zero DO and destroyed an important fishery (Tamayo-Zafaralla, 1983).

There are many industrial discharges but, of several thousand monitored from 1980 to 1983, only about half were treated.

3.1.4.2 Laguna de Bay

Laguna de Bay has long experienced fish kills, the first reports being about 50 years ago (Villadolid, 1933), the cause being 'bad water', which was associated with low DO caused by the die-off of excessive growths of algae, induced, it is generally thought, by eutrophication. There were kills in 1973 and 1974 (Delmendo, 1979), but in recent years the problem has occurred only in locally restricted areas, although there has been a decline in fish production between 1980 and 1983. Nevertheless, the fish appear to feed on Microcystis and acquire an unpleasant taint in the flesh. In the centre of Laguna de Bay, near Talim Island, green, rather than blue-green, algae predominate. This water body receives industrial wastes, as well as a large number of tributary streams of variable quality, and pesticides are also used in part of the catchment area. Its hydrology, which is complex, has been markedly altered over the last two years through the operation of a flood-control structure at its outlet which prevents the ingress of seawater, and this will be further changed when a channel to divert flood flows from an adjacent river is completed. Thus it will be some time before the impact of waste input on water quality and fisheries can be understood and modelled, although that is a long-term objective of the LLDA. The University of the Philippines at Los Baños has a Limnological Research Station on the lake shore and a multi-disciplinary team is available to study the ecology of this lake both in the field and in the laboratory.

3.1.4.3 Future developments

Future developments are likely to increase the potential for water pollution. The Philippines is one of the world's leading growth areas with a population growth of 2.6% and ever-increasing industrial output which has risen slightly from 35.5% of the total economic output in 1978 to 36.4% in 1981 but was expected to rise to 52% by the turn of the century (Sanchez and Fajardo, 1982). Particular development was expected in mining and quarrying, including the opening of mines for gold and copper and in the conversion from oil to coal burning. Although these forecasts have had to be revised in the light of the present economic difficulties (Philippines, 1984), the main impact on freshwater is still likely to be from mining operations (see Section 3.2.3).

New industries having a high potential for pollution are prohibited within a 80-km radius of Manila, which should help to contain the situation there.

3.2 Suspended Solids

High concentrations of suspended solids are commonly present in rivers in Southeast Asia, particularly as a result of land erosion, following deforestation and mining operations. The countries most affected appear to be Malaysia, Indonesia and the Philippines.

3.2.1 Malaysia

In Malaysia, suspended solids cause major problems in a number of rivers draining tin-mining areas and also those adjacent to where there are extensive land development activities, yielding up to 1 550 t/km^2 per year in some cases (Chuen and Johan, 1983).

There are no federal statutory powers of control, the mines legislation conferring these on the Mines Department which now requires settling ponds for the tailings; however, the effluent standard is 11 400 mg/l (Maheswaran and Ho, 1983) which is obviously quite inadequate. Government personnel feel that, in the case of land development and deforestation, the Public Works Department should require the installation of silt traps.

Fish-fry production stations, which normally require a supply of good quality water, are particularly at risk from suspended solids; compared with 20 years ago, they now silt up and require regular cleaning.

3.2.2 Indonesia

Land erosion is a general problem in Indonesia, about 1.3% of the land surface being heavily affected. The figure is as high as 6% in Java, where up to 230 mm of soil can be removed in a year, compared with between 3 and 87 mm elsewhere in the country; this gives rise to concentrations of suspended solids of 1 500 - 30 000 mg/l in rivers in Java compared with 150-10 000 mg/l elsewhere in the country (Badruddin, 1983).

These high concentrations are considered to be one of the reasons why the river fisheries in Java are relatively unimportant, an opinion based on experimental work and field observations by the Faculty of Fisheries of the University, Bogor, which given funding, intends to continue its studies of this question using floating cages.

Land erosion is exacerbated by deforestation and indiscriminate (illegal) land clearance which may also be associated with the programme of human resettlement from the most heavily populated areas of Java and Madura, where average densities are about 600 persons/km^2 compared with figures of 39/km^2 in Sumatra and Sulawesi and 9/km^2 in Kalimantan (Caponera, 1978). Already 2.5 million inhabitants out of a planned total of 7.4 million have been involved in the transmigration (Caufield, 1984). However, such developments are accompanied by EIAs which should reduce the risk of land erosion from this cause.

The Ministry of Forestry is involved in much reafforestation work and also in building check dams, as well as in promoting demonstration plots showing how erosion can be reduced (Badruddin, 1983).

3.2.3 Philippines

A major problem causing heavy losses of fish in the Philippines is that of suspended and settled solids from mine tailings and land erosion accompanied, in some rivers such as the Abra, Agno, Amburayan and Bued, by the presence of cyanide which is used in the metal-recovery process (Tamayo-Zafaralla, 1983).

The School of Forestry predicts the total loss of forests (and resultant increased land erosion) by the early 1990s, unless present trends are reversed. The Ministry of Natural Resources has plans requiring logging companies and 'slash and burn' farmers to replant. There is concern, however, that planting is not enough, because survival is poor and more after-care of the young trees is required.

3.3. Heavy Metals, Pesticides and PCBs

3.3.1 Thailand

Surveys have been made in recent years of the four principal rivers flowing into the upper Gulf of Thailand in order to measure the concentrations of heavy metals, DDT and PCBs in the water, as well as the sediments and biota, including fish. This has been carried out by several bodies, including AIT (Polprasert et al., 1981; Polprasert, 1982) and Chulalongkorn University (Menasveta and Cheevaparanapiwat, 1981, 1982). It is, however, difficult to draw unequivocal conclusions until more is known about the behaviour of these materials in the rivers and also the extent of comparability of the analyses. More data are being collected by NEB and others to try to clarify the situation (e.g. Hungspreugs and Yuangthong, 1983; J.H. Phillips and K. Muttarasin, personal communication). There is some evidence, however, for an increase in DDT and PCBs and, over the past 30 years, of cadmium and lead. The relatively high levels of lead that have also been found in human hair of Bangkok inhabitants (Menasveta, 1983) may well have been derived mainly from the atmosphere. Mercury levels may decline in the future since effluent from a chlor-alkali plant is now being treated, resulting in a reduction of 95-99% in mercury emission.

Data on the amount of pesticide imported between the years 1974 and 1983 (Thailand, 1984) show a general increase in insecticides, especially pyrethroids (although these comprise only a small part of the total) but a decrease in chlorinated hydrocarbons, especially for the years 1980-83: there was a slight increase in herbicides generally, except for inorganic salts (which again comprise only a small proportion of the total).

The Department of Agriculture has found that, over the last five years, aqueous concentrations of the DDT group have declined but that those of dieldrin, endrin (now banned) and aldrin have increased, and that levels in marketed fish have also increased slightly. Work has already begun on the toxicity of pesticides to indigenous species of fish and the accumulation of these substances in fish and a considerable number of studies has been carried out (see Section 5.1). Field monitoring and collaboration with fishery interests will continue.

Monitoring of pesticides in the Nam Pong River, a tributary of the Mekong (Mekong Secretariat, 1982), has shown the presence of low concentrations, but the river-course runs partly along the border of Thailand with Laos and then through Kampuchea and Viet Nam, and pesticides are suspected of having been responsible for reduced fish production in the delta area. Monitoring for pesticides in water will continue under the auspices of the Mekong Committee, and national governments will follow up the results.

3.3.2 Malaysia

There has been some monitoring of heavy metals by DOE (Chuen and Johan, 1983) and maximum concentrations in some rivers have exceeded 0.01 mg/l for lead, zinc, mercury, hexavalent chromium and cadmium. Analyses for metal content of fish have been initiated by the Fisheries Research Institute and indicate levels of the same order as found in marine species (Jothy et al., 1983), although some of the results for cadmium may be relatively high (S. Devi, pers.comm.).

Pesticides, largely organo-chlorine and organo-phosphorus compounds used in crop protection and vector control are liable to be washed into rivers (Jothy, 1978). They are also applied to paddy fields where there have been large declines in fish production, partly attributable to the change from single to double or triple cropping (which allows a much shorter time for fish to grow between harvests), and partly to the use of increasingly potent chemicals for pest control.

Judging from a recent survey (Heong et al., 1982), virtually all rice farmers use pesticides, most applying it 4-5 times during a season, preferably as emulsifiable concentrates, although granules and wettable powders are used. A variety of compounds is used, including endosulfan (Yunus and Lim, 1971), which is one of the substances most toxic to fish (Alabaster, 1969); not surprisingly, fish kills have been reported (e.g. by Yunus and Lim, 1971), but no detailed data are available, although there are some studies on the effect of new pesticides on the ecology of invertebrates (e.g. Lim et al., 1984; Lim and Wong, in press).

There are no quantitative data available on the amounts of pesticides imported, formulated and used in Malaysia, but it is generally considered that these are increasing. The Crop Protection Division of the Department of Agriculture is responsible for registration of pesticides and requires information on toxicity to fish, inter alia, and cooperates with the Fisheries Research Institute in deciding on acceptable uses of pesticides. The Institute hopes to be able to carry out its own tests this year under static conditions, starting with carp (Cyprinus carpio) and gourami (Trichogaster). It has no facilities of its own for pesticide analysis but is expecting to receive the necessary equipment later this year.

Pesticide analyses of fish obtained from paddy fields have just begun at the Fisheries Research Institute and preliminary results indicate that concentrations of organochlorine compounds are generally of the same order as found in marine species, except for endosulfan, for which they appear to be significantly higher (I. Rodiah, pers.comm.).

3.3.3 Indonesia

Heavy metals occur in some rivers but in certain cases natural sources are suspected as being responsible, for example mercury in the Musi River (from volcanic sources), copper in West Java and cadmium in East Java.

There have been incidents of fish kills in the past and suspected reduction in fish productivity from the use of pesticides in rice fields (S. Koesoemadinata, pers.comm.) but, with the establishment

in 1970 of the Pesticides Committee of the Ministry of Agriculture and the Government Decree (No.7) of 1973 requiring the regulation of all pesticides, the safety of new formulated pesticides is evaluated and those for use on irrigated rice fields are screened for toxicity to fish by the Ministry's Inland Fishery Research Institute, Bogor.

The test species are common carp, Java carp (Puntius gonionotus) and tilapia; acute toxicity is measured under static conditions in the laboratory followed by tests in rice fields using the recommended dose according to procedures laid down by the Committee in 1983. Facilities for flow-through tests, though regarded as necessary, are not yet available. Experience has shown that field trials are essential. No residues analyses are carried out, although they are regarded as desirable. Recommendations on the use of a pesticide are agreed between the Institute, the Faculty of Fisheries of the University, Bogor, and the Indonesian Institute of Science (Tropical Biology) of the Ministry for Research and Development (BIOTROP), Bogor. At present no organochlorine compounds are used, only organo-phosphorus compounds and carbamates (a complete list of registered formulations, giving active ingredients, target pests, manufacturers and general directions on safety is published bi-annually, e.g. Indonesia (1984) but in practice only a few dozen of these are used).

On average, about 30 pesticides per year have been tested between the years 1970 and 1982 (e.g. BIOTROP, 1975; Wardoyo et al., 1981) and the number may now be decreasing. No tests are carried out by the Institute on pesticides used for other purposes, although these could involve risks to fish. Insecticides are predominant among the pesticides used on food crops and have increased from about 1 400 t/year in 1974 to 9 000 t/year in 1981 (Partoatmodjo and Alemoeso, 1982) and amount to about 13 000 tonnes today. The forecast is for a further increase of about 10%/a. Total quantities quoted in the press as distributed to farmers were about 43 000 t in 1983 and 91 000 t in 1984 (Thu, 1985).

Published variations in background values for DDT in the saline environment are probably attributable to the use of DDT in malaria control (Duursma and Hanafi, 1978), a practice that continues, together with the use of malathion. PCBs, however, were rarely found at that time.

The use of DDT for vector control is centred on Java and the transmigration areas but the annual quantity applied has decreased from 15 000 t in 1959-65 to 5 000 in 1965-75 and is now about 2 000 t; the use of fenitrothion, however, has increased from about 100 t in 1978 to about 350 t at present.

Aqueous concentrations of some pesticides were measured in 1977-80 in the rivers Citarum and Cimanik (Sumatra, 1985) and in 1980-81 by the Institute of Ecology, Bandung (with funding from the Ministry of Population and Environment), but no analyses were carried out on fish. The Ministry feels the need for such work on fish for which both funds and specialized training would be required. Recently (January '85) an inventory was made of government and industrial organizations capable of carrying out pesticide analyses as an initial step in the coordination of pesticide monitoring by the Pesticides Committee.

The Faculty of Fisheries also carries out in-depth studies of the toxicity of pesticides, covering all stages of the life cycle of fish and taking account of production, reproduction, histopathology, haematology and uptake in both field and laboratory experiments, the total duration being up to 5 years. Aquatic herbicides and 'hard' detergents have also been studied. Some results are expected to be published in English.

3.3.4 Philippines

Heavy metals, particularly copper, reach relatively high concentrations, exceeding allowable limits in some rivers, particularly the Pasig River, linking Laguna de Bay with Manila Bay (Philippines, 1984b) and there has been some study of the concentrations in aquatic life (Kapauan et al., 1979). In Laguna de Bay, metals are known to have been present at low concentration but have not been monitored since 1977; pesticides there are a cause for concern, simply because no data on their concentrations in water and fish have yet been collected.

Pesticide usage has been increasing from 1977 to 1983 in which year, of pesticides sold, 44% were insecticides and 24% herbicides, the corresponding figures for those used on rice being 27 and 13%, respectively (Gaston, 1984); carbofuran is the main pesticide used on rice, but others, e.g. endosulfan (Thiodan) are also recommended. Their use is controlled by the Fertilizer and Pesticides Authority; DDT, for example, is allowed to be used only for malaria control, and advice on rates of application and target organisms is published. Some consider that the use of pesticides on rice has

been excessively high in the past, and certainly there are instances of a drastic reduction in yields of both fish and edible snails, but usage has now been reduced.

The International Rice Research Institute (IRRI) has recently established a committee on water quality and proposes to monitor pesticides in water associated with rice culture, but at present it seems unlikely to extend this programme to include analyses of residues in fish. This is a subject that might be included in the programme of the FAO/UNEP/WHO Panel of Experts on Environmental Management for Disease and Vector Control (PEEM) which at present appears to be concerned with pesticides only in relation to vector control and not in relation to adverse side effects on fish. The IRRI has no formal links with the Fertilizer and Pesticides Committee but there is an exchange of information at a biennial workshop with the Ministry of Agriculture.

However, the Committee does receive recommendations from the Freshwater Aquaculture Centre of Luzon State University which is actively involved in testing the toxicity of pesticides to fish. Also, studies on translocation and biomagnification are being carried out in model ricefield ecosystems by the University of the Philippines in Los Baños. A number of toxicological studies has been reported, e.g. 13 have been abstracted by Darvin and Rodriguez (1984) and seven others have been carried out by NPCC, as indicated by de la Cruz and Cagauan (1981) who have themselves given results for a further seven insecticides and five herbicides.

3.4 The Role of Pesticides in Fish Disease Outbreaks

The possibility that pesticide usage in agriculture (and also in malaria control), which appears to be high in Thailand, has been involved in the recent outbreak of disease in fish there (Hubbert, 1982) remains an open question. Somewhat similar diseases have appeared in Queensland, Australia (Rodgers and Burke, 1981), Papua New Guinea (Uwate, 1983), Malaysia, Indonesia (FAO, 1984), Kampuchea (Economist Intelligence Unit, 1984) and Burma (Thu, 1985) where pesticides do not always appear to be implicated.

Fish that died in Thailand in 1982 showed levels of chlorinated hydrocarbons much the same as those of normal fish, but checks were not made for other pesticides such as 2,4-D and paraquat (N. Tayaputch, pers.comm.). The Department of Agriculture has found that, over the last five years, aqueous concentrations of the DDT group have declined, but that those of dieldrin, endrin (now banned) and aldrin have increased and that levels in marketed fish have also increased slightly. The whole question is soon to be investigated by FAO consultants in Thailand.

In Malaysia, pesticides have been implicated in the disease of fish occurring in rice-fields from December 1980 to February 1981. However, chlorinated hydrocarbons were apparently not detected in the fish at the time, so their possible role remains unexplained as yet. Another disease has broken out in a rice-growing area in the State of Perak in February 1985 and is providing a further opportunity to investigate the causes.

Late in 1980 there was an epidemic of disease in Indonesia among fish in both ponds and open water, as well as in rice fields. Aeromonas organisms and fungi were involved, and catfish (Clarias batrachus) are apparently still affected. It was suspected that pesticides might have been involved as a contributory factor, although high organic loads (as indicated by high BOD and COD) and pH values lower than 6.8 also seemed to be associated factors. No special studies have been carried out, but tests by the Institute of Fisheries showed that the herbicide 2,4-D and the organo-phosphorus pesticide diazinon (Basudin) did not produce lesions in either carp or snakehead (Channa striata) but no tests were carried out on any other pesticides.

3.5 Conclusions

The general absence of sewerage has led to problems of deoxygenation of rivers and fish kills, a problem also encountered with wastes from agriculture- and forestry-based industries, including, particularly, those of sugar, palm-oil and rubber. However, in some countries, lagoon systems for treatment are being increasingly used to good effect (Section 3.1).

Suspended solids from land erosion and mine tailings also cause serious problems affecting fish in parts of Southeast Asia (Section 3.2).

The range of industrial wastes is ever widening and significant concentrations of heavy metals have been recorded in some rivers (Sections 3.1; 3.3.1; 3.3.2) but the precise impact of specific substances on the fisheries is not known.

The trend is for high rates of population growth and increasing urbanization and industrialization, so increasing the potential for localized pollution problems in the future.

Pesticide usage is generally increasing but in some countries, e.g. Thailand, there is a reduction in chlorinated hydrocarbons, although residues of some of these continue to show an upward trend in water and fish. In some other countries residue analyses in fish have only just begun.

Screening of pesticides for toxicity to fish is either being practiced, often very thoroughly, as in Indonesia, where field trials are included, or is planned to be introduced shortly. Altogether, there appears to be a large number of studies completed, but the results are often not readily accessible to Southeast Asia as a whole, because they are either unpublished or are available only in national languages.

4. USE OF WASTES FOR FISH PRODUCTION

A considerable amount of research has been carried out at AIT on the use of sewage and sewage sludge for fish production (e.g. Edwards et al., 1980; Polprasert et al., 1982; Edwards et al., 1983); recent work has centred on the use of sludge applied directly to fish ponds and also to ponds in which duck-weed is grown for feeding to fish in separate ponds. The second of these methods is favoured for social and health reasons. A pilot scheme has been started in a village in which there are 10 units, one to each family, rather than having a common facility, so as to reduce the risk of spreading organisms such as Salmonella from a human carrier.

Lagoons used to treat sewage in Malaysia have been found to contain fish but because they are sometimes inadequately designed, being too deep, the fish have been known to suffer periodic mortalities at night.

The need for further studies on the integration of aquaculture with the husbandry of other animals, such as pigs, whose wastes cause acute local water pollution problems, as in Thailand (Section 2.1) and Malaysia (Section 3.1.2) has been identified (Edwards et al., 1983).

With lagoon treatment of wastes from sugar-cane processing in Thailand, involving prior nutrient addition, a high crop of fish (at least 700 kg/ha in one 15-ha pond) was reported from the aerobic ponds in the downstream half of a series (Section 3.1.1.2).

As in Thailand, fish have been found to thrive in Malaysia in treatment lagoons, in this case those for treating palm-oil and rubber wastes: tilapia do particularly well, as do catfish in diluted effluent and there is now some commercial fish production in lagoons used for treating wastes from rubber (Yap et al., 1983). However, catfish kept in such lagoons may develop yellow fat making them suitable only for frying, rather than steaming.

5. WATER QUALITY CRITERIA

5.1 Thailand

The need for water quality criteria for tropical inland fisheries has been raised by Pescod (1978) and is being considered by NEB, which appears to be basing its proposals on the values suggested (as illustrative only) by Pescod (1978). He pointed out, moreover, that until more research had been carried on the tolerance of tropical freshwater fish to pollutants, care should be taken in choosing stream standards. Furthermore, he gave no explanation of the basis and rationale involved in the formulation of his tentative values.

There is dearth of relevant information available on the environmental requirements of fish in Thailand, particularly from the field, although a number of studies, mainly M.Sc. theses, have been carried out on various chemicals, e.g. by Duangsawasdi (1977), Surapatana (1980), Duangsawasdi and Sripoomun (1981), Srisuwantach et al. (1981), Kwansiroroje (1982), Peturiyanate (1982), Chittapalalong (1983) Saisonbat (1983), Utayopas (1982) and Peera (1984). Much less work has been carried out on effluents, e.g. Tookvinas et al. (1976) or in the field, e.g. Tantanasarit (1982). These studies have centred on the AIT, the Faculty of Fisheries at Kasetsart University, the Faculty of Pharmacological Science, Chulalongkorn University and the Universities of Silapakorn and Srinakarinwirot.

Recently a review of work in Thailand has been drafted (Sinhaseni and Tanasakal, 1985) which shows that some 66 reports containing 527 studies have been completed. However, almost all were acute toxicity tests and often carried out under static conditions, and almost half were concerned with pesticides. Nevertheless, conclusions can be drawn concerning the choice of suitable tests species for long- and short-term tests; the authors conclude that Puntius gonionotus and Pangasius sutchi, both sensitive fish of economic importance, are suitable for acute toxicity tests in their young stages, while Labeo frenatus and L. bicolor also have good potential for long-term testing. A Symposium on Living Aquatic Resources has been arranged for March 1985 in Thailand by the Chulalongkorn University, in which a third of the proceedings will be devoted to toxicity testing, covering inter alia the scope for standardization, including the choice of test species.

There was a strong positive response to the suggestion that there should be a similar meeting in about two year's time, but on an international scale, covering Southeast Asian countries and dealing with the development of water quality criteria, including aspects such as the use of application factors as well as the choice of test species, test conditions and duration of tests.

5.2 Malaysia

DOE has started to consider the development of water quality standards for specific uses, including fisheries, and has commissioned the University of Malaya to produce a discussion document within nine months. It is envisaged that both scientific criteria and practical standards will be called for.

A preliminary note on water quality standards has already been prepared by the Fisheries Research Institute (Liong, 1984), although it is agreed that more work should be carried out. Such work could include:

(1) collation of existing data on the relation between water quality in aquaculture and the production of fish, as well as consideration of data on water quality in rivers and the status of wild populations of fish (i.e. presence or absence, number of species, size of populations, standing crop and annual yield, as available), including those obtained from detailed studies such as that of Bishop (1973) in the river Sungai;

(2) critical reviewing of the relevant world literature, including that from the southern states of the U.S.;

(3) laboratory tests on indigenous species, using water quality characteristics chosen in the light of field information, and

(4) the initiation of special field studies to fill in some of the gaps in knowledge and to support conclusions drawn from laboratory findings.

Nevertheless, it is realized that, in the meantime, interim standards are required, taking account of socio-economic factors, as well as existing scientific criteria.

Considerable interest was shown by the Institute of Fisheries Research in extending its present capability for carrying out static tests to include continuous-flow procedures, using simple, reliable apparatus, such as that developed by the Water Research Centre (e.g. Shurben, 1978). There was also an evident need for expert guidance in setting up such facilities and in training staff in its operation and maintenance.

There had been no contact with Thai workers in this field and the possibility of holding an ASEAN Workshop to exchange ideas and information and to discuss water quality criteria was welcomed.

It was also felt that a visit from an expert experienced in the restoration of inland fisheries would be beneficial since the Institute proposed to rehabilitate the fisheries of rivers as soon as their water quality improved.

5.3 Indonesia

Standards of water quality for freshwater fish have been drafted by a temporary committee of the Ministry of Environment and Population (Badruddin, 1983), drawing on Pescod (1978) and other sources; it was agreed, however, that the values chosen are not necessarily realistic and that there is a need for scientifically well-founded criteria for Asian species.

Priority subjects were considered to be suspended solids, organic pollution (i.e. DO, carbon dioxide and ammonia), pesticides, heavy metals and 'hard' detergents (which may be used by households at the rate of 5 kg/family and month, causing foaming in some rivers).

The Centre for National Resource Management and Environmental Studies of the Agriculture University, Bogor, has been studying the effect on streams of wastes from the processing of tapioca in South Sumatra where there are fishless zones, but it has not yet collected sufficient information to help develop water quality criteria.

There was strong support, not only for an international workshop, but also for the formation of a working group of Southeast Asian scientists to start a long-term programme to promulgate tentative criteria for Asian species of fish for priority water quality characteristics. It was suggested that advice from an expert from the European Inland Fisheries Advisory Commission (EIFAC) on the general approach to the development and application of such criteria would be desirable.

A specific plea for water quality criteria for pesticides and inland fisheries has been made by S. Koesoemadinata (pers.comm.) who recommended the establishment of a Southeast Asian data-bank for the accumulation and dissemination of results of toxicity evaluations.

5.4 Philippines

The water quality requirements of freshwater fisheries and aquaculture have been derived from world sources, making some general allowance for tropical conditions, but they are regarded as preliminary and in need of up-dating based on data from Southeast Asia, a view strongly expressed by Catalan (1984).

The NPCC has carried out some relevant research on fish, e.g. on their resistance to low DO and high concentrations of suspended solids, cyanide, heavy metals and industrial wastes, using fingerling milkfish Chanos chanos, carp and tilapia, but the work has not been fully published, although a few results have been quoted (de Leon and Abiog, 1983) or abstracted (see Darvin and Rodriguez, 1984). Some data have been obtained on the toxicity of ammonia to milkfish (Cruz, 1981). The NPCC, given the necessary funding, would like to extend this work on criteria using both static and flow-through procedures, as indeed would the LLDA and the University of the Philippines, Los Banos. Again guidance is sought on the setting-up of simple flow-through dosing units.

There is scope for carrying out field observations to assist in developing water quality criteria. The data on river water quality currently being collected by NPCC, and that on suspended solids being collected by the Forestry Research Division of the Philippines Council for Agriculture and Resources Development, could be utilized for this purpose were information also available on the fish present at the monitoring stations. In a similar way, the situation in Laguna de Bay offers the opportunity to try to relate fish production, e.g. in the experimental fish-pens, to water quality, and thus develop realistic criteria in situ; this is a major concern of the LLDA and could also be of general value in fish culture elsewhere. Metals, though present in Laguna de Bay, are not regarded as of high priority there, but are felt to be important in some of the rivers. Other priority water quality characteristics in Lagula de Bay would be DO, suspended solids and pesticides.

5.5 Conclusions

The setting of water quality standards for freshwater fish is being actively pursued in Southeast Asia, but there is wide recognition that the scientific basis is at present inadequate and needs to be improved (ASEAN/EEC, 1983).

There is a considerable amount of data on the effect of water quality on Asian species of fish, especially on the acute toxicity of substances, particularly pesticides. However, much of it is not readily accessible within Southeast Asia as a whole, either because it is published in national languages or remains unpublished. There is therefore a need to disseminate this information more widely in the area and to see to what extent it can be used to formulate guidelines on usage and the development of water quality criteria, as well as to identify specific gaps in knowledge of the subject.

Although a workshop of Southeast Asian countries would offer the opportunity for an initial effective exchange of information, more permanent arrangements need to be considered, such as the regular production of annotated bibliographies and the establishment of a standing international committee or working group to keep the question of water quality criteria under active consideration.

There is a wide measure of agreement on priority subjects for consideration; these include suspended solids, DO, heavy metals and pesticides.

6. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary and Conclusions

6.1.1 Legislation and administration

Much progress has been made in combatting industrial pollution in Southeast Asia, but it was often considered that there was a need to strengthen the law, e.g. where there was, as yet, no comprehensive pollution control enactment and no central government body having environmental protection as its main function.

There was a general lack of multi-disciplinary river basin management bodies having responsibility for the prevention and control of pollution as well as other functions relevant to river basin management, including fisheries, a situation that many thought was unsatisfactory.

Resources currently available for monitoring, control and research on water pollution were generally considered to be inadequate.

Solid wastes, including domestic refuse and diffuse sources posed special problems of control in some countries.

6.1.2 River basin modelling

River basin modelling of water quality was generally not well developed although several studies had been carried out, or were in progress, e.g. in the Mekong and Chao Phraya in Thailand (Section 3.1.1), Linggi River in Malaysia (Section 2.2), Citarum River in Indonesia (Section 3.1.3.1) and Laguna de Bay in the Philippines (Section 3.1.4.2). The main concern in rivers was DO, but other water quality characteristics, including nutrients, metals and pesticides were also of interest, e.g. in Laguna de Bay. In general, multi-disciplinary teams that were larger and had a longer-term commitment than those used to-date would be required in order to make significant progress in the future.

6.1.3 Effluent and environmental standards

An initial tendency to adopt uniform standards has given way to a more flexible approach whereby progressively more stringent standards are set for particular industries and situations, based on the best available treatment technology, the dilution available and realistic water quality criteria for water uses, including fisheries.

The formulation of water quality standards for freshwater fish is now being actively pursued, but the present scientific basis is considered to be inadequate and needs to be improved.

Data on the effect of water quality on Asian species of fish are not readily accessible and need to be disseminated more widely in Southeast Asia with a view of helping in the formulation of guidelines on the usage of pesticides and the developing of water quality criteria.

Exchange and pooling of information and experience in Southeast Asian countries, which is necessary for the establishment of water quality criteria for Asian species of fish, could be achieved through specially-arranged international meetings and the establishment of more permanent means of liaison, such as a working group of appropriate specialists.

There is a wide measure of agreement on priority subjects for consideration; these include suspended solids, DO, heavy metals and pesticides.

6.1.4 Waste treatment and the production of fish

Lagoons have been used successfully for the treatment of oxidizeable wastes, and there is a need to disseminate the results to other countries where such methods are most appropriate.

There is also interest in the use of high-rate anaerobic treatment processes, as currently being developed in Europe.

The production of fish in lagoons used to treat sewage and industrial wastes is still largely in the experimental and development stages but needs to be pursued further.

6.2 Recommendations

(1) A Workshop on Water Quality Criteria for Asian Inland Fisheries should be held within two years among ASEAN countries to discuss the methodology of toxicity testing and the approach to developing water quality criteria for Asian species of freshwater fish, in preparation for the setting up of an FAO Working Group on Water Quality Criteria for Asian Inland Fisheries.

(2) There should be a digest made of information on lagoon treatment of domestic and industrial wastes in Southeast Asia with a view to its dissemination to those developing countries where such methods are likely to be effective and where a need for such information has already been demonstrated, as in the case of East Africa (Alabaster, 1981).

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Annex

Persons and Places visited
(14 January - 12 February 1985)

THAILAND, 14-20 January

FAO Regional Office for Asia and the Pacific, Maliwan Mansion, Phra Atit Road, Bangkok 10200
- Mr. I. Csavas, Regional Aquaculture Officer
- Mr. V.L.C. Pieterz, Regional Fishery Officer
- Mr. G. Spiller, Consultant
- Dr. Wahn Li Zhu, Regional Plant Protection Officer and Executive Secretary, Asia and Pacific Plant Protection Commission

Dr. K. Ruddle, Associate Professor, National Museum of Ethnology, Senri Expo Park, Suita, Osaka 565, Japan

Kasetsart University Campus, Bangkhen, Bangkok 10900
- Dr. Thiraphan Bhukaswan, Director, National Inland Fisheries Institute
- Dr. Maitree Duangsawasdi, Fishery Biologist, National Inland Fisheries Institute
- Ms. Nuansri Tayaputch, Chief of Pesticide Research Section, Department of Agriculture
- Dr. Sutham Sidthichaikasem, Instructor, Faculty of Fisheries

Mr. Ponchai Taranatham, Head, Environmental Policy and Planning Division, Offices of the National Environmental Board, Soi Prachasamphan, Rama VI Road, Bangkok 10400

Chulalongkorn University, Bangkok 5
- Dr. Piamsak Menasveta, Head, Department of Marine Science, Faculty of Science
- Ms. Palarp Sinhaseni, Secretary General, Toxicological Society of Thailand, Faculty of Pharmacological Science

Ms. Nantana Santatiwut, Head, Environmental Health Division, Department of Health, Ministry of Public Health, Bangkok 2

Mekong Secretariat/ESCAP, United Nations Building, Bangkok
- Dr. V.R. Pantulu, Chief, Environmental Unit
- Dr. G. Engelmann, Consultant, Environmental Unit

Environmental Engineering Division, Asian Institute of Technology, P.O. Box 2754, Bangkok
- Dr. Chongrak Pholprasert
- Ms. Samorn Muttamara
- Dr. N.C. Thanh
- Ms. Chintana Pacharaprakiti

Dr. Munsin Tantoolavest, Associate Professor, Engineering Faculty, Chulalongkorn University, Pathumwan, Bangkok 10500

Ministry of Industry, Bangkok
- Mr. Chumnong Manuschutaboon, Director-General, Industrial Works Department
- Mr. Pravit Siprajan, Chief, River and Coastal Conservation, Industrial Environment Division

Locations:
(1) Tha Chin River at Ban Bang Yang
(2) Central waste treatment plant for sugar industries at Chanwat Kanchanaburi on the Mae Klong
(3) Khwae Noi River at Kanchanaburi

MALAYSIA, 21-27 January

Dr. C.K. John, Head, Crop Protection and Microbiology Division, Rubber Research Institute, 260 Jalan Ampang, Kuala Lumpur 16-03

Fisheries Department, Ministry of Agriculture, Jalan Mahameru, Kuala Lumpur
- Shahrom bin Haji Abdul Majid, Deputy Director-General of Fisheries
- Mr. Cheah Eng Kean, Senior Fisheries Officer, Planning and Development Division
- Mr. K.T. Siow, Senior Fisheries Officer, Extension and Training Section

Fisheries Research Institute, Glugor, Penang
- Mohammed Shaari bin Sam Abdul Latiff, Director
- Dr. A.A. Jothy, Senior Fishery Officer
- Mr. Liong Pit Chong, Senior Fishery Research Officer
- Ms. Idris Rodiah, Fishery Research Officer
- Mr. Ibrahim Rohani, Fishery Research Officer
- Ms. Shahunthlala, Fishery Research Officer
- Ms. S. Devi, Fishery Research Officer

Department of Environment, Ministry of Science, Technology and the Environment, 1st floor, Mui Plaza, Jalan P. Ramlee, Kuala Lumpur
- Mr. G. Singam, Principal Assistant Director, Pollution Control Unit
- Mr. Hashim Daud, Environmental Control Officer
- Mr. Zainal b. Abdullah, Environmental Control Officer
- Mr. Z. Abdul Rahman, Environmental Control Officer

Zoology Department, University of Malaya, Lembah Pantai, Kuala Lumpur
- Dr. A. Sasekumar, Marine Biologist
- Dr. R.P. Lim, Limnologist

Dr. A. Balasubramaniam, Senior Agricultural Officer, Crop Protection Division, Department of Agriculture, Gallagher Road, Kuala Lumpur

Mr. M. Nural Alam, Assistant Regional Representative, UNDP Malaysia, Singapore and Brunei, Blocks K-9&10, Government Offices Complex, Jalan Duta, P.O. Box 12544, Kuala Lumpur

INDONESIA, 28 January - 5 February

Dr. D.B. Reddy, FAO Representative in Indonesia, 14 Jalan M.H. Thamrin, Jakarta

Ministry of Agriculture, Directorate General of Fisheries, 16 Jalan Salemba Raya, Jakarta
- Mr. T.D. Pandjaitan, Chief, Fisheries and Environment Protection
- Mr. Soewito, Director, Living Resources Management
- Mr. Tommy H. Purwaka, Environment Protection Sector
- Mr. Ben bin Abdul Nalik, Environment Protection Sector

Agency for Agricultural Research and Development, Ministry of Agriculture, Jalan Sempur 1, P.O. Box 51, Bogor
- Mr. A. Dwiponggo, Coordinator for Department of Agriculture,
- Mr. Abe Poernomo Tirtoredjo, Director, Inland Fisheries Research Institute,
- Mr. Atmadja Hardjamulia, Fishery Biologist, Inland Fishery Research Institute,

Faculty of Fisheries, Bogor Agricultural University, Jalan Raya Pajajaran, Bogor
- Dr. Kardiyo Praptokardiyo, Limnologist
- Mr. Hambali, Fish Pathologist

Mr. T.H. Wardayo Supomo, Biotrop, P.O. Box 17, Bogor

Mr. Koesoebiono, Programme Manager for Coastal Zone Management Programmes, Centre for Natural Resources Management and Environment Studies, Agricultural University, Bogor

Institute of Hydraulic Engineering, Jalan Ir. H. Huanda No. 139, Bandung
Mr. Sadeli Wiramihardja, Director
Dr. Mahbab Badruddin, Division of Water Quality and Environment

Dr. Sadji Partoatmodjo, Director, Food Crop Protection and Chairman, Pesticides Committee, Ministry of Agriculture, Jalan Ragunan, Pasar Minggu, Jakarta

Department of Pollution Control and Hazardous and Toxic Substances, Ministry of Population and Environment, Jalan Merdeba Barat 15, Jakarta Pusat
Ms. Masnellyarti Hilman
Mr. B. Widyantoro

Dr. William L. Chan, Team Leader, FAO/UNDP Sea Farming Development Centre, Lampung

Dr. S. Arwati, Director, Vector-borne Disease Control, Directorate General, Communicable Diseases, Ministry of Health, Jalan Percetakan Negara 29, Kotak Pos 223, Jakarta Pusat

PHILIPPINES, 6-12 February

Mr. A. Cruz, Programme Assistant, Office of FAO Representative in the Philippines, P.O. Box 1864, Makati, Metro Manila

International Centre for Living Aquatic Resources Management, P.O. Box 1501, Makati, Metro Manila
Dr. R.S.U. Pullin, Director, Aquaculture Programme
Ms. Rosalinda M. Temprosa, Chief Librarian

National Pollution Control Commission, 727 Pedro Gil Street, Ermita, Metro Manila
General G.A. Pecache, Commissioner
Ms. H.R. de Leon, Chief, Research and Development Division, and Officer-in-Charge, Planning and Statistics Division
Mr. Carlos A. Panaligan, Chief, Water Pollution Control Division

Bureau of Fisheries and Aquatic Resources, Marcelo Building, Quezon Avenue, Quezon City
Mr. D.M. Garcia, Officer-in-Charge, Propagation Division,
Mr. E. Villamafen, Jr., Chief, Freshwater Fisheries Section
Ms. J. Lavarro, Senior Fishery Biologist

Mr. J.D. Centeno, Jr., Manager, Environment Protection Division, Laguna Lake Development Authority, 3rd Floor, Rizal Provincial Capitol, Pasig

Ms. A.D.D. Supetran, Science Research Specialist, Environment Impact Assessment Group, National Environment Protection Council, 6th Floor, Philippine Heart Centre Building, East Avenue, Quezon City

University of the Philippines, University Campus, Diliman, Quezon City
Ms. F.R. Uyenco, Director, Office of Research Coordination, Natural Sciences Research Centre
Mr. Pepito M. Fernandez, Associate Professor, Inland Fisheries/Aquaculture, 108 Valenzuela St.

Dr. Hammond Murray-Rust, Associate Agricultural Engineer, Irrigation Water Management, International Rice Research Institute, Los Baños, Laguna

University of the Philippines College, Los Baños, Laguna
Dr. J. Eusebio, Dean College of Human Ecology
Dr. M. Tamayo-Zafaralla, Assistant Professor, College of Arts and Sciences
Dr. Zenaida Batac Catalan, Head, Limnological Research Station, College of Arts and Sciences

Philippines Council for Agriculture and Resources Development, National Sciences and Technology Authority, Los Baños, Laguna
Dr. E. Tan, Director, Fishery Research Department
Dr. F. Pollisco, Director, Forestry Research Division

National Economic and Development Authority of Pasig, Amber Avenue, Pasig, Metro Manila
Dr. Remedios de Leon, Director, Industry and Utilities Staff
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